SPECIFICATION

TITLE OF INVENTION: INTERNALLY RESILIENT TIE FOR RAILWAY TRACK

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CROSS-REFERENCE TO RELATED APPLICATIONS Not Applicable

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT Not Applicable

REFERENCE TO SEQUENCE LISTING, A TABLE, OR A COMPUTER PROGRAM LISTING COMPACT DISC APPENDIX Not Applicable

BACKGROUND OF THE INVENTION

The elastic response of railway track, also referred to as track stiffness, track elasticity or spring rate of the track, is often erratic. Also erratic is the dynamic response of the track due to variations of the types and depths of subsurface materials. Such irregularities lead to differences in the track's deflection under a passing train, and to variations in the dynamic response of the track. These differences dynamically excite rolling stock. The resulting forces and vibrations

lower comfort and safety of the travel, increase track maintenance intensity, constitute a major obstacle in the upgrading of existing track for higher speeds, and/or lead to speed restrictions.

Track stiffness variations caused by inaccuracies of upper track structure, which consists of rails, ties, ballast, and subballast, can be controlled by routine track maintenance. However, the track stiffness irregularities due to stiffness variations of subgrade and under-laying materials in situ are very difficult to address. Extensive excavation and replacement of soils located below the track are often necessary to obtain a track formation of desired uniformity and quality. Such work cannot be performed within track maintenance windows of an operated railroad line. Temporary closures of the line are necessary what is very difficult to afford especially on heavily traveled lines.

Various attempts to influence track stiffness by the rail pad, an elastomer placed between the rail and the railway tie, or between the rail and a tie plate, or a combination of the both, have been made without much success. The elastomeric rail pad must be very hard to survive at this location and to provide lateral stability of the rail. A rail pad sufficiently softened to provide the desirable and generally reduced overall track resiliency cannot be used so that influencing the overall stiffness of the track structure to achieve its overall uniformity at the rail pad's level is not practical. Various fasteners have been invented that introduce a second elastomer under a steel plate placed on the top of the tie in addition to the rail pad. These fasteners do not include any stiffness adjustment features to compensate for the random variations of the track stiffness due to the under-laying materials in situ. Also, the mass of the added plate is too small to generate a damper phenomenon in its combination with the top and bottom elastomeric pads. The resulting lack of dampening within the track structure leads to intense dynamic loading

effects, early deterioration of such rail fastening features, and spread of objectionable vibrations into the environment.

Large occurrence of random variations of stiffness and variations of the dynamic response of the track observed on majority of existing railway lines prompted the providers of high-speed rail services in Europe and Japan to construct new lines. Strict standards were adopted to ensure uniformity of subgrade and subsoil layers into considerable depths, and to avoid poor soil areas. The presence of tight curves on existing lines played smaller role in the decision-making process than generally perceived because many tight curves can be traveled fast using tilting technology incorporated in certain high-speed trains. The random variations of overall track stiffness and its dynamic response lead to running instabilities and increase track maintenance costs. These variations constitute general impediments of the track quality and essential obstacles to high-speed operations. The previous art offers only costly replacements of variable under-laying materials or their modifications in situ as remedies.

BRIEF SUMMARY OF THE INVENTION

This invention consists of an internally resilient tie (IRT) for railway track and its alternatives. The internally resilient tie is a device for achieving uniformity of elastic and dynamic response of the track system. It compensates for random stiffness variations of the track and its formation, enhances dampening, reduces dynamic impact and abates vibrations at an expanded frequency range so that vibrations entering the surrounding environment are minimized.

The internal resiliency built into the concrete or steel railway tie allows to adjust track stiffness to a desirable value, and to intentionally vary the spring rate and dynamic response of

the tie assembly, at an added elastomeric level. The physical feature that provides the variability of internal resiliency, favorable dynamic response and dampening of the tie assembly is a booted block placed under each rail and encased or inserted in a concrete or steel tie. This block is supported by bottom elastomeric pad placed inside the elastomeric boot. The bottom elastomeric pad can be as soft as determined by the design, and its properties varied as needed while the elastomeric top pad under the rail can be as hard as necessary to endure high frequency dynamic effects and abrasion in its contact with the rail. The block suspended between the two elastic members acts as a damper. The parameters of this dampening system are controlled by the properties of the bottom elastomeric pad and by the block's mass. Variations of the properties of the bottom elastomeric pad are made in such a manner that they compensate for site-specific random variations of the overall stiffness of the track and its formation, and assist in the compensation for the dynamic variations of the track's under-laying soils and soil/rock interfaces. Also, the system is suitable for transitions between track placed on soils and track on firm foundations such as bridge abutments, tunnel inverts and slabtrack.

Since the block is large, the size of the bottom elastomeric pad is large as well. As a result, the unit stresses at the bottom elastomeric pad are small so that its fatigue life is very long.

The use of internally resilient ties will reduce or eliminate the need to perform capital intensive excavations, as well as re-processing, partial or total replacement of soils to achieve uniformity of their elastic and dynamic behavior when loaded by trains, and to dampen forces at resonant frequencies.

The internally resilient ties are supported by ballast, or placed on piles, pile caps or other firm structural foundations what is particularly advantageous in poor soil areas. This solution has a potential to reduce or eliminate conventional replacement of weak soils, their drainage, or

construction of elevated structures. Internally resilient ties are fully capable of substituting for ballast action.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

Drawing No.1 – Internally Resilient Tie with Independent Booted Blocks and Concrete Case. This drawing shows the alternative of booted steel, hybrid steel/concrete, wood or plastic blocks (2) encased in a *concrete* tie case (1). This alternative is shown in a plan view (bottom of the drawing), in longitudinal section –Section A-A'- (top of the drawing) and in a cross section – Section B-B' (left middle area of the drawing). The plan view and the sections are symmetrical about their centerlines. The blocks (2) are independent of each other and placed in elastomeric enclosures-boots (4). The hard top elastomeric rail plate (5) is placed directly under the rail (3). The soft bottom elastomeric plate (6) is placed inside the boot (4) under the block (2). The rail (3) is attached to the block, preferably with threadless elastic fasteners with spring clips (7). Threadless elastic spring clips (7) would likely lead to a lower track maintenance intensity then alternative fasteners equipped with bolts and nuts. The fastening of the rail to the block and its clips (7) are optional and do not constitute parts of this patent.

The block is prevented from being pulled up from the tie to facilitate lifting the tie assembly by the rail during track installation and maintenance. This feature is ensured by the function of two block retainers per block (8). A block retainer is a device that transfers the vertical uplift force from the blocks to the tie case when the entire assembly is lifted by the rail. However, the block retainer is also capable of a complete withdrawal of the block (2) from the tie case anytime the bottom elastomer (6) must be replaced, usually to compensate for altered properties of under-laying materials. Furthermore, the block retainer (8) does not compress the

elastomers (4, 5,6), and does not restrain the block's (2) upward movement that is needed to follow the rail's (2) uplift wave that exists at a certain distance away from the location of its loading by a wheel. Otherwise raising of the entire tie assembly would accelerate deterioration of track geometry that is common on a track equipped with conventional ties. Also, the block retainer (8) ensures that the length of the upward travel of each lifted block within the retainer's upward movement allowance is constant for all blocks.

Drawing No. 2 Internally Resilient Tie with Independent Booted Blocks and Steel Case. This drawing shows the alternative of booted steel, hybrid steel/concrete, wood or plastic blocks (2) encased or inserted in a *steel* tie case (1). This alternative is shown in a plan view (bottom of the drawing), in longitudinal section –Section A-A'- (top of the drawing) and in a cross section – Section B-B' (left middle area of the drawing). The plan view and the sections are symmetrical about their centerlines.

Except for the tie case made of steel and the block retainer attached to it by a suitable means of steel to steel connection, all features and their descriptions pertinent to this alternative are the same as the ones described for the Alternative Internally Resilient Tie with Independent Booted Blocks and Concrete Case, Drawing No.1.

Drawing No. 3 Detail of Section A-A' Showing Retainer of Claim 18 - Internally Resilient Tie with Independent Booted Blocks and Concrete Case. This Drawing provides more clear view of the longitudinal section through the tie at one block and block retainer (8) than Drawing 1. The block retainer (8) consists of a cast-in shoulder with two spring steel leaf plates stated in the Claim 18. However, other types of the block retainer's design are possible to serve the same purpose and they are covered under the Broad Claim 16. This drawing also shows the features of the rain water diversion and enhancement of electrical insulation properties of the

block by the non-metallic collar (12) and by the shape of the rubber boot's edge (4) of the Dependent Claim 20.

Drawing No. 4 Detail of Section A-A' – Showing Block Retainer of Claim 19 – Internally Resilient Tie with Independent Booted Blocks and Steel Case. This Drawing provides more clear view of the longitudinal section through the tie at one block and block retainer (8) than the Drawing 2. It consists of a bolted-on shoulder with two spring steel leave plates stated in the Claim 19. However, other types of the block retainer's design are possible to serve the same purpose and they are covered under the Broad Claim 16. This drawing also shows the features of the rain water diversion and enhancement of electrical insulation properties of the block by the non-metallic collar (12) and by the shape of the rubber boot's edge (4) of the Dependent Claim 20.

Drawing No. 5 Plan view relevant to block retainers of Claim 18 and Claim 19- Internally Resilient Tie with Independent Booted Blocks and Concrete or Steel Case. This Drawing provides more enlarged plan view of the booted block (2) cast into or inserted in a concrete or steel case (1) and of the block retainers (8) of Claims 18 and 19 whose plan views in this projections are the same. However, other types of the block retainer's design are possible to serve the same purpose and they are covered under the Broad Claim 16. This drawing also shows the non-metallic collar (12) for the rain water diversion and enhancement of electrical insulation properties of the Dependent Claim 20.

DETAILED DESCRIPTION OF THE INVENTION

The Internally Resilient Tie consists of the following components as shown on Drawings 1 through 5 to provide the purposes described as follows:

A. Two booted booted steel, hybrid steel/concrete, wood or plastic blocks (2) placed in a steel or concrete tie case (1) supporting the rail (3).

B. Rubber boot (4), top elastomeric rail pads (5) and elastomeric bottom pads (6).

This Internally Resilient Tie provides three-dimensional resiliency at each rail. The vertical resiliency is separated into two layers. The upper layer, a stiff rail pad (5) of standard hardness, is placed between the rail (3) and the top of an independent booted block (2). This pad abates predominantly high frequency vibrations. The lower layer consists of an elastomeric pad (6) placed under the block within the boot (4). This pad abates predominantly low frequency vibrations. Lateral resiliency is provided by elastic response of the vertical side of the boot (4). The booted blocks (2) have to be independent one of the other in order to allow development of the lateral resiliency of a block in case that the rail (3) is impacted transversely by an unloaded wheel. If the booted blocks under the parallel rails were made of one piece or connected together, the impacted block would not be able to dissipate kinetic energy by its lateral yielding. This is because the other vertically loaded wheel of the same axle would prevent the very small but indispensable side-way movement needed for the lateral dynamic impact reduction purposes from occurring. As a result, the lateral dynamic forces critical for longevity of track fasteners would be much higher than in the case of independent booted blocks.

The internally resilient tie is an effective damper. The dampening function is provided by the mass of the block (2) suspended between the two elastomeric pads (5) and (6). Since many kinds of resonance that exist in the railway track and become very pronounced at high speeds cannot be fully eliminated, the effective dampening will reduce their duration and significance. In a broad sense, this invention provides means of operational speed range extension, and/or reductions of track maintenance. In a narrow sense, the internally resilient ties for railway track

improvement rail deflection uniformity by controlling the total elastic response of the track by varying elasticity of the bottom elastomer within the resilient railway tie, in lieu of modifying or replacing subgrade and/or subsoils under the track. Also, this invention facilitates the desirable increase of the track's nominal elasticity by selection of appropriate resiliency at the bottom elastomer within the tie, instead of an alternative introduction of a soft top rail pad. Applications of soft rail pads have been tried without much success in the past.

Internally resilient ties can be placed on ballast in a traditional manner, or used in ballastless applications. In weak soils, or where the carrying participation of ballast and/or surface soils is undesirable or unfeasible, the internally resilient ties can be placed on piles, pile caps, longitudinal beams, firm foundations, bridge decks or tunnel inverts because the internally resilient tie is fully capable of substituting for ballast action. Also, the internally resilient ties provide stiffness and dynamic response transition between ballasted and ballastless kinds of railway track.

C. Elastic rail fastening clips and shoulders (7)

Any type of elastic rail fastenings (7) of a desired toe load can be utilized to attach the rail (3) to the blocks (2). However, these rail fastenings should be preferably threadless to eliminate maintenance difficulties associated with frozen bolts during track maintenance, namely rail replacement. Rail fastenings do not constitute a part of this patent.

D. Block Retainer

The block retainer (8) is attached to the concrete tie case (1) by its component placed inside the concrete of the tie case (1) as shown in the Drawing 3 for Claim 18, or by a suitable steel to steel connection in the case of steel tie case. Such a connection is the bolted-on shoulder shown in the Drawing 4 for Claim 19. Except for this bolt-on feature, otherwise thread-less

block retainers would likely lead to lower track maintenance intensity than the ones relying on bolts and nuts.

a. Purposes served by the block retainer

1. Vertical stop

In order to facilitate lifting of the tie assembly by attached rails, that is necessary during its initial installation, tamping and replacement by mechanized track maintenance equipment, a stop has to be used that prevents the blocks from being pulled up from the case. Also, the block retainer (8) ensures that the length of the upward travel of each lifted block within the retainer's upward movement allowance is constant for all blocks. This would allow adjust standard tamping machines for just one value of the travel to achieve proper track geometry during the track installation and maintenance. Otherwise every tie assembly would have to be tamped individually.

2. Rail float

A loaded rail deflects downward in the area of the applied wheel load and rises slightly at a certain distance from this point. This shape of the rail's deflection curve is characteristic of a beam on elastic supports. It is advantageous to allow the block to rise during the rail's uplift phase without allowing the tie case to rise because avoidance of any uplift at the tie/ballast interface leads to major reduction of track maintenance. For this reason, the stop must not restrict the block from its vertical movement completely. A sufficient space must exist between the bottom surface of the restricting member of the vertical stop and the mating surface of the block. This rail float feature is the subject of Claim 17.

b. Block Retainers Pertinent to Dependent Claims 18 and 19, Parts (16) and (9) through (15). For ease of installation, and for avoidance of difficult maintenance efforts associated with threaded components frozen by corrosion, threadless devices such as driven flat springs (9,10) inserted into a curved slot in a cast iron insert (16) are used, as shown on the attached drawings. During installation, the lower spring leaf (9) is inserted first. Then the upper leaf (10) is driven in. It deflects and causes the leaf (9) to deflect as well. The leaves (9) and (10) stay within the slot by thus introduced pre-load. An eventual shifting of the leaves that would loosen the plates is prevented by the pin (11) inserted into the aligned holes in the leaves (9) and (10) and the shoulder (16). The contact point on the block's top can be lowered or raised by inserting member (14) of an adjusted depth into the slot created by two members (15).

E. Rain water diversion and enhancement of electrical insulation properties of the block by the non-metallic collar (12) and by the shape of the rubber boot's edge of the Dependent Claim 20

The insulating non/metallic collar (12) is provided around the entire perimeter of the block to keep rainwater from entering the tie's interior along the vertical surfaces of the boot.

The dry surfaces under the overhang of the insulating non/metallic collar (12) and under the lip of the rubber boot (4) will enhance the electrical insulating properties of rail fasteners, and the protection against the surface leakage of stray currents on electrified lines.

F. Procedure for IRT application in the areas of relatively good sub-soils to achieve uniformity of vertical stiffness of the track that is necessary for high-speed rail operations:

In order to ensure successful incremental upgrading of existing railway lines for high speed operations, upgrading of the uniformity of the elastic and dynamic response of the track is necessary. It shall be achieved as follows:

a. The existing vertical track stiffness shall be determined at each tie

b. The desired uniformity of the track shall be determined and compared to the lowest stiffness measured. If this stiffness is still acceptable for the relevant type of rail operations, then this stiffness shall be accepted to become the nominal vertical stiffness of the track.

c. The tolerable deviation of the individual track stiffness from its nominal value will be established

d. The necessary change of vertical stiffness will be calculated at each tie to achieve the uniform nominal stiffness within the specified tolerance.

e. Replacement pads corresponding to the individual values of vertical stiffness will be determined and color-coded.

f. Ties will be marked with corresponding colors

g. The bottom pads (6) of each resilient concrete tie will be replaced with pads of required hardness